

AD-A245 439



IDA DOCUMENT D-1042

SOFTWARE MATURITY MODEL APPLIED TO SDI

DTIC
ECTE
S D
JAN 23 1992

Beth Springsteen
Dennis W. Fife, *Task Leader*

September 1991

Prepared for
Strategic Defense Initiative Organization

Approved for public release, unlimited distribution: 28 October 1991.



INSTITUTE FOR DEFENSE ANALYSES
1801 N. Beauregard Street, Alexandria, Virginia 22311-1772

IDA Log No. HQ 91-040280

AD-ESDI 471
Copy 29 of 91 copies

2

DEFINITIONS

IDA publishes the following documents to report the results of its work.

Reports

Reports are the most authoritative and most carefully considered products IDA publishes. They normally embody results of major projects which (a) have a direct bearing on decisions affecting major programs, (b) address issues of significant concern to the Executive Branch, the Congress and/or the public, or (c) address issues that have significant economic implications. IDA Reports are reviewed by outside panels of experts to ensure their high quality and relevance to the problems studied, and they are released by the President of IDA.

Group Reports

Group Reports record the findings and results of IDA established working groups and panels composed of senior individuals addressing major issues which otherwise would be the subject of an IDA Report. IDA Group Reports are reviewed by the senior individuals responsible for the project and others as selected by IDA to ensure their high quality and relevance to the problems studied, and are released by the President of IDA.

Papers

Papers, also authoritative and carefully considered products of IDA, address studies that are narrower in scope than those covered in Reports. IDA Papers are reviewed to ensure that they meet the high standards expected of refereed papers in professional journals or formal Agency reports.

Documents

IDA Documents are used for the convenience of the sponsors or the analysts (a) to record substantive work done in quick reaction studies, (b) to record the proceedings of conferences and meetings, (c) to make available preliminary and tentative results of analyses, (d) to record data developed in the course of an investigation, or (e) to forward information that is essentially unanalyzed and unevaluated. The review of IDA Documents is suited to their content and intended use.

The work reported in this document was conducted under contract MDA 903 99 C 0003 for the Department of Defense. The publication of this IDA document does not indicate endorsement by the Department of Defense, nor should the contents be construed as reflecting the official position of that Agency.

© 1991 Institute for Defense Analysis

The Government of the United States is granted an unlimited license to reproduce this document.

REPORT DOCUMENTATION PAGE		Form Approved OMB No. 0704-0188
<small>Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing the burden, to Washington Headquarters Service, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Project (0704-0188), Washington, DC 20503.</small>		
1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE September 1991	3. REPORT TYPE AND DATES COVERED Final
4. TITLE AND SUBTITLE Software Maturity Model Applied to SDI		5. FUNDING NUMBERS MDA 903 89 C 0003 Task Number T-R2-597.2
6. AUTHOR(S) Beth Springsteen		7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Institute for Defense Analyses (IDA) 1801 N. Beauregard St. Alexandria, VA 22311-1772
8. PERFORMING ORGANIZATION REPORT NUMBER IDA Document D-1042		9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) Strategic Defense Initiative Organization (SDIO) The Pentagon, Room 1E149 Washington, DC 20301-7100
11. SUPPLEMENTARY NOTES		
12a. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release, unlimited distribution: 28 October 1991.		12b. DISTRIBUTION CODE 2A
13. ABSTRACT (Maximum 200 words) <p>The Strategic Defense Initiative Organization (SDIO) is undertaking initiatives to mitigate software risks and to stimulate the DoD contractor community to improve its software practices. To that end, IDA assessed the Software Engineering Institute's (SEI) software process maturity model and developed an implementation plan for its use within the SDI program. Under this plan, SDI element programs will use the SEI method to select software contractors with mature practices and to monitor contracts after they have been awarded. This document describes the SEI maturity model and the experiences of contractors and government agencies. It also explains SDIO's plans to implement the model program-wide and the benefits and lessons learned from using the model on two contracts.</p>		
14. SUBJECT TERMS Software practices; Software evaluations; Maturity model; SDI.		15. NUMBER OF PAGES 76
17. SECURITY CLASSIFICATION OF REPORT Unclassified		16. PRICE CODE
18. SECURITY CLASSIFICATION OF THIS PAGE Unclassified		19. LIMITATION OF ABSTRACT SAR

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2/89)
Prescribed by ANSI Std. Z39-18
298-102



Accession For:	
NTIS	<input checked="" type="checkbox"/> CRA&I
DTIC	<input type="checkbox"/> TAB
Unannounced	<input type="checkbox"/>
Justification	
By	
Distribution	
Availability Codes	
Dist	Avail and/or Special
A-1	

IDA DOCUMENT D-1042

SOFTWARE MATURITY MODEL APPLIED TO SDI

Beth Springsteen
Dennis W. Fife, *Task Leader*

September 1991

Approved for public release, unlimited distribution: 28 October 1991.



INSTITUTE FOR DEFENSE ANALYSES

Contract MDA 903 89 C 0003
Task T-R2-597.2

92 1 22 031

92-01797



Preface

This IDA document is an annotated briefing which describes the Software Engineering Institute's (SEI) software process maturity model and lays out a plan for applying the model to the SDI program. The intended audience is SDI program managers and software personnel who have a general understanding of software and the problems associated with it, but who are unfamiliar with the SEI maturity model and the benefits it presents.

This document pertains to one of several subtasks being carried out under Task Order T-R-597.2, *SDIO Software Technology Plan*, and in particular relates to the objective in that task order to "investigate practical means for SDIO to encourage improvement in SDI contractors' software development practices."

IDA review of this document was carried out by Dr. Richard L. Wexelblat.

Software Maturity Model Applied to SDI

This presentation describes the Software Engineering Institute's (SEI) software process maturity model and its applicability to SDI. Key portions of the presentation have been given to many SDI program managers. As a result, the software process maturity model is now being used by at least 9 of the SDI program offices as a means of measuring and improving the practices of their software contractors.



Software Maturity Model Applied to SDI

**Beth Springsteen
IDA/CSED**

UNCLASSIFIED

Outline

The presentation is divided into 4 sections. The first two help to define SEI's software process maturity model and the experience that companies and DoD services have had when using it. The third section describes SDIO's vision for using the maturity model program-wide. And the last section presents the benefits and lessons learned from performing two evaluations using the maturity model.



Outline

-
1. SEI Software Process Maturity Model
 2. Software Process Evaluation Activities
 3. SDI Implementation Plans
 4. Benefits and Lessons Learned

Importance of Process Improvement

SEI at Carnegie Mellon University is a Federally Funded Research and Development Center (FFRDC). It was established by the Department of Defense (DoD) in 1984 to address software development issues which plague DoD's software intensive systems. One of their tasks was to identify a means of evaluating a contractor's ability to effectively develop software. In June 1987, the SEI defined an approach for determining the maturity level of a contractor's software process. (Humphrey 87)

The underlying hypothesis on which this methodology is based is that the quality of a software system is governed by the quality of the process used to develop and maintain it. The SEI methodology evaluates a contractor's software development process as it is used on several projects, identifies the weaknesses of the process, and ranks its overall maturity.

Maturity levels range from mature to immature. A mature process institutionalizes good software engineering techniques and produces software with reasonably consistent results; whereas, an immature process lacks good software engineering practices and produces software with unpredictable results (i.e., over budget and behind schedule).

Importance of Process Improvement



The quality of a software system is driven by the quality of the process used to develop and maintain it

- Mature process**
 - effective use of technology**
 - reasonably consistent results**
- Immature process**
 - results unpredictable**
 - technology use is ad hoc and high risk**
 - likely problems with cost, schedule, and quality**

[Humphrey 90]

SEI's Maturity Model

The SEI model describes five maturity levels of an organization's software development and maintenance process. Level 1-Initial is the least mature and level 5-Optimizing is the most mature organization. In general, the least mature organization has more risk, lower productivity, and lower quality software than those more mature. Based on the results of a 1989 survey of 167 DoD projects, SEI found that 86% of contractors are at Level 1 and 13% are at Level 2. (Humphrey 89c). Following is a brief description of each maturity level. (Humphrey 89a).

Level 1 - Initial: The least mature organization is characterized as having an "ad hoc" and "chaotic" processes. Since there are very few software engineering practices in place, it is very dependent on the people within the organization. It generally lacks good software project management, configuration management, quality assurance, and project planning practices. When the projects of this organization succeed, "it is because of the heroic efforts of the team rather than the capability of the organization". (Humphrey 90a).

Level 2 - Repeatable: This organization has established basic project controls and is therefore thought to have a repeatable software development process in place. It is less dependent on individuals and has rigorous management oversight of commitments, change control, quality, and cost estimation. The strength of this organization comes from doing similar work, but it faces major risks when presented with new challenges.

Level 3 - Defined: A Level 3 organization has the foundation for defining the complete process and deciding how to improve it. Its process is more qualitative than quantitative in nature.

Level 4 - Managed: This organization has a quantitative focus on their development process. The measurements extend beyond cost, schedule and performance and focus on quality and productivity. SEI indicates that the most significant quality improvement occurs at this level of maturity.

Level 5 - Optimizing: This organization is focused on continued improvement and optimization of the process.

SEI's Maturity Model



			Productivity & Quality	Risk
5 Optimizing	Continuous process capability improvement	Process improvement Defect prevention		
4 Managed	Product quality planning and tracking of measured software processes	Process measurement and analysis Quality management		
3 Defined	Development process defined and institutionalized to provide product quality control	Process focus Process definition Training Peer reviews Standards & Procedures		
2 Repeatable	Management oversight and tracking of project; stable planning and product baselines	Project management Project planning Config. management Quality assurance Subcontractor mgmt.		
1 Initial	Ad hoc (unpredictable, chaotic)	"People"		

[Humphrey 89b]

SEI Framework

To determine the maturity level of a contractor's process, SEI developed a questionnaire and guidelines for the evaluation team. The questionnaire consists of 110 questions which focus on the characteristics of each of the Key Process Areas; e.g., project management, configuration management, and defect prevention. The questions help to identify the organization's commitment to the software process by exploring the resources, standards, tools, and training efforts.

The general method for determining an organization's maturity level revolves around a specially-trained evaluation team. The team consists of at least 5 software development experts trained by SEI. Each evaluation takes approximately 3 days. This time is spent interviewing software personnel and reviewing the contractor's software documents. For example, when exploring the contractor's configuration management process, team interviews configuration managers and software developers to understand their process for making changes to software designs, code, and test cases. To substantiate answers to the interview questions, the evaluation team reviews the *Configuration Management Plan* and supporting documentation such as the minutes from the last Configuration Change Board Meeting as well as the *Version Description Document*. The combination of the interviews and supporting documentation helps to ensure that the process documented is the one that is used.

The contractor's maturity level is based on the development process used on several projects. 5-7 projects are reviewed using the questionnaire and the evaluation team selects personnel to interview from 3-5 projects. Thus, to achieve a maturity level 2, all the projects must be at that level. It is not sufficient to have only one mature project, since the focus of the evaluation is to identify the organization's overall commitment to building quality software, not just the commitment of a single project.



Software Framework

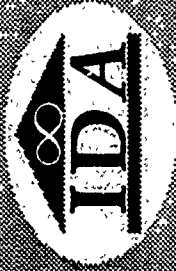
<u>Key Process Areas</u>	<u>Questions for each Key Process Area</u>
Project Management	Organizational Structure
Project Planning	Resources
Configuration Management	Personnel
Quality Assurance	Training
Subcontractor Management	Technology Management
Peer Reviews	Documented Standards
Software Requirements	Process Metrics
Software Design	Data Management and Analysis
Software Development	Process Control
Process Measurement	Tools
Defect Prevention	

Methods for Using Maturity Model

A contractor's process maturity can be determined two different ways: either by a self-assessment or a capability evaluation. (Humphrey 90) Both of these methods use the SEI framework and questionnaire. They differ however in their implementation approaches and how the results are used.

Self - Assessment is performed by a team of experts within the contractor's organization. The objective is to identify the organization's maturity level and the weaknesses in the development process. The results of a self-assessment are confidential and may be used to generate a self-improvement plan.

Capability Evaluations are performed by an external team of software experts. The team is a government only team; no contractors are allowed. The objective of a capability evaluation is to validate the results of a self-assessment or to determine firsthand the weaknesses of the contractor's process. These results are also confidential. Only the contractor and the DoD program office receive them. The program office uses the evaluation results for input to the source selection advisory board and for monitoring contractors already on board.



MEMORANDUM FOR USING MATURITY MODEL

Self - Assessments

- For internal process improvement
- Team: internal to contractor
- Assess process maturity
- Findings: identify inhibitors
- Results are confidential



Input to improvement action plan

Capability Evaluations

- For selection and contract management
- Team: external to contractor
- Substantiates current practices
- Findings: strengths and weaknesses
- Results given to Program Office



Input for source selection, contract award, or risk management

[Humphrey 90]

Contractors' Self-Assessment Activity

Since the SEI maturity model was developed, there has been a tremendous demand from the contractor community to implement the self-assessments. To date, SEI reports more than 45 DoD contractors have been trained to perform self-assessments including divisions of Hughes, IBM, McDonnell Douglas, Northrop, GTE, JPL, and TRW.

Due to the high level of interest, SEI has licensed ten companies to train self-assessment teams and to assist contractors performing self-assessments. These companies include, American Management Systems, Arthur D. Little, Contel, Digital Equipment Corporation, and the Software Productivity Consortium.



Contractors' Self-Assessment Activity

No. Contractors

SEI-led assessments

14

Trained organizations

33

Conducted self-assessments

18

Planned self-assessments

5

Not yet established action plan

10

47

[SEI 91a]

UNCLASSIFIED

Lockheed's Motivation for Change

It is frequently asked whether the SEI maturity levels are closely correlated with the contractor's ability to build quality software on-time and within budget. Even though the model is based on sound software engineering techniques (e.g., configuration management, quality assurance, peer reviews), several contractors have attempted to quantify the costs of improving their SEI maturity rating and to determine the impact it has had on the quality and cost of their software products.

For example, Lockheed's Missile and Space Company found that as a less mature organization they had more defects per thousand source lines of code (KSLOC) than when they were a more mature organization. Specifically, this site of Lockheed progressed from a level 1 to a level 3 organization within a few years. For a typical size project of 500 KSLOC, the level 1 organization experienced on average 9 defects per KSLOC which cost approximately \$32.5 million to correct. Whereas, the level 3 organization only experienced 1 defect per KSLOC which cost only \$6.5 million to correct. Therefore, to achieve the same level of quality, the level 1 organization incurred costs which were approximately 5 times (32.5/6.5) more than that of their level 3 organization. (Pore 90)

At this point, Lockheed's Missile and Space Company does not have quality data for a level 4 or 5 organization. Therefore, the information provided for the higher maturity levels was extrapolated from their previous experience.

Lockheed's Motivation for Change



Estimates based on typical 500 KSLOC project

<u>SEI Level</u>	<u>Defects/KSLOC</u>	<u>Cost</u>
5	.1-	\$ 1.0 M-
4	.3	\$ 2.5 M
3	1	\$ 6.5 M
2	3	\$15.0 M
1	9+	\$32.5 M

Lockheed
Missiles & Space Company, Inc.
Software Technology Center

[Pore 90]

Hughes Cost/Benefit of Improvement

Hughes Ground Systems Group documented the costs and benefits of advancing from a level 2 organization in 1987 to a level 3 organization in 1990. Overall, Hughes estimates that for every dollar spent on improving their process, they saved 5 dollars in development expenses. (Willis 90)

Cost: The expenses Hughes experienced were itemized in two categories; the cost to perform the evaluations and the cost of implementing their improvement plan. (Humphrey 91a) The improvement plan focused on 5 areas:

- Process Group: an organizational entity to focus on software process improvement.
- Quantitative Process Management: a focal point for collecting and reporting software project accomplishments, problems, trouble reports, quality indicators, scope changes, resource needs, and lessons learned.
- Training Gaps: a report based on review of current training needs, training effectiveness, and implement a training curriculum.
- Standardized Reviews: formalization of the organizations approach of the peer review process.
- Software Engineering Discipline: incorporation of software engineering issues into the system engineering process.

Benefits: The benefits were measured in terms of the Cost Performance Index (CPI = Budgeted Cost of Work Performed / Actual Cost of Work Performed). The CPI showed a steady improvement from 0.94 in 1987 to 0.97 in 1990. This 50% reduction net Hughes approximately \$2 million annually. (Humphrey 91a) (Willis 90)

Hughes Cost/Benefit of Improvement



Cost:

Actual cost to go from Level 2 to Level 3
based on 1987 findings - applied over 2 yrs

75 mm

Actual cost of SEI-Assisted Assessment

\$ 45 K

Benefit:

Cost Performance Index, July 1987

0.94

Cost Performance Index, March 1990

0.97

Cost Performance Index = Budgeted / Actual cost of work performed

[Willis 90]

HUGHES
Ground Systems Group

Capability Evaluation Activity

Specific military services have been using capability evaluations extensively. As reported by SEI, over 198 people have been trained and more than 27 DoD acquisitions have used the evaluations for source selection or contract monitoring. (SEI 91a)

As a result of its success, several DoD organizations and services have policy mandating that software capability evaluations be used. The Naval Air Development Center (NADC) requires capability evaluations to be performed on all software acquisitions greater than one million dollars. The Army's CECOM requires them on software acquisitions greater than ten million dollars. The Air Force has plans to release a policy in 1992 which requires all contractors to be at least at level 3 in order to bid on contracts.

Capability Evaluation Activity



Organizations	People Trained	Number of Acquisitions	Policy
Navy	52	15	All s/w > \$1M
- Naval Air Development Center			
- Naval Weapons Center			
- AN/BSY-2			
- NOSC			
- SPAWAR			
Army	38	2	All MCCR s/w > \$10M
- CECOM			
Air Force	113	6	Air Force Acquisition: all software contractors > Level 3*
- Logistics Command/MM			
- Electronic Systems Division			
- Electronic Systems Division/Mitre			
- Aeronautical Systems Division			
NASA	7	2	
- Agency Office of Safety, Reliability, and Quality Assurance			
Swedish Defence Materials Admin.	4	2	
Others	11		
	198	27	

[SEI 91a] *updated to reflect change in policy

Outline

This section describes the activities involved in performing software process evaluations. It identifies activities performed prior to the contractor's site visit as well as those performed during and after the visit.



Outline

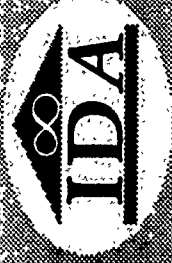
1. SEI Software Process Maturity Model
- 2. Software Process Evaluation Activities
3. SDI Implementation Plans
4. Benefits and Lessons Learned

Pre-site Visit

Since the Capability Evaluation lasts only 3 days, preparatory work must be done in advance.

Information Request: Approximately 2 months in advance of a site visit, the contractor receives a list of information which is to be sent to the evaluation team prior to the visit. The contractor must identify 5-7 projects similar to the project under contract; i.e., similar size, similar development process. For each of these projects the contractor submits the SEI questionnaire, an organization chart, and a project profile (described in more detail on the following page).

Initial Evaluations: Within two weeks of the visit, the evaluation team analyzes the contractor's project profiles and the SEI questionnaires. They identify weaknesses and weed out projects that do not seem applicable. The project organizations charts are then used to identify individuals responsible for specific key processes. Within 1 week of the site visit, the contractor is given a preliminary interview schedule and a list of documentation which should be available when the evaluation team arrives.



Information Request for 5-7 projects:

- Completed SEI questionnaire
- Organization Charts
- Project Profile
- Software Development Plan

Initial evaluation:

- Summary of questionnaire
- Select key projects
- Establish initial interview schedule
- Develop supporting documentation list

Project Profile Summary

The project profile provides the evaluation team a brief description of the 5-7 projects subject to review. It helps to compare each project in terms of size, language requirements, and phase of development. This information helps the team determine which projects should be reviewed in more detail during the site visit.



Project Profile Summary

5-7 Project Profiles:

- Project name and description
- Customer
- Subcontractors & prime contractor
- Current development phase
- Development schedule: start, design, code, end
- Size: development team, KSLLOC
- Programming languages
- Hardware: target and development
- Development standards: e.g., 2167A
- Cost: actual/estimated
- SEI Questionnaire: 110 questions
- Organization chart

General Site Visit Agenda

The site visit extends over three very busy days. Each day consists of at least a 12 hour workday full of interviews and documentation reviews.

Day 1: Kick-off briefing and high level interviews. The first presentation is given by the evaluation team leader and the second by the contractor's software leader. The evaluation teams presentation introduces each of the teams members and describes the purpose of the visit. The contractor's presentation is an overview briefing on the organizations software development philosophy and organization structure. The remainder of the day is spent interviewing several project managers in order to understand the reporting relationships and responsibilities.

Day 2: Exploratory interviews. Approximately half of these interviews are arranged in advance of the site visit. These include key members of the organization who were identified in the organization charts; for example, Configuration Manager, Quality Assurance Manager, Project Leader, and Site Director. The rest of the interviews are established at the end of Day 1 or before noon of Day 2. These interviewees are identified in conversations with the project leaders and the key functional leads. The remainder of the day is spent reviewing documentation that was requested in advance of the visit or during the interviews. By the end of the day, the team prepares their preliminary findings.

Day 3: Exit Briefing. Before noon, the project leaders and perhaps some of the functional leaders are interviewed for a second time so that the evaluation team may clarify any questions. By noon, the team reviews their findings and any remaining documentation. The Exit briefing is attended by the contractors higher level management. It provides an opportunity for the evaluation team to brief the contractor on their findings.

General Site Visit Agenda



Day 1:

SCE Briefing

Corporate Overview Briefing

**Interview: Program Managers
(Project A, B and C)**

Day 2:

Initial Documentation Review

Exploratory Interviews:

(e.g., CM, QA, Planning, Metrics, Standards)

Detailed Documentation Review

Day 3:

Consolidation Interviews

Exit Briefing

Focus of Interviews

The interviews help to determine if practices actually used within an organization are accurately reflected in the project questionnaire and the project documents. Since the wording of the SEI questionnaire is often subject to misinterpretation, it is very common for an individual to respond negatively when in fact they satisfy the intent of the question. In addition, it is very common for the practices called out in the Software Development Plan for example to be different than those used on a day-to-day basis.

Each interview is initiated with a brief overview of the SEI evaluation process. During this time it is important to inform the interviewee that the discussions are private and the findings are confidential. The evaluation results will not identify specific individuals nor projects. The purpose of the interview is to understand more thoroughly the actual practices employed on a project and to determine the degree to which software development practices are institutionalized across all projects.

Focus of Interviews



Inputs

Questionnaires
Key Issues
Probing questions
Basic Documentation
Supporting Documentation

Objectives

Validate responses
Investigate key issues
Request process substantiation
Establish preliminary findings

“Non-attribution”

[SEI 91]

Exit Briefing

The Exit Briefing presents the findings of the SEI Evaluation in a standard format that includes strengths and weaknesses for each key process area reviewed. In addition, if the contractor has improvement activities underway, these are identified for each key process area.

The findings provide the contractor an independent viewpoint of the state of their software development practices. Any weaknesses identified during the evaluation serve the basis for a Contractor's *Improvement Plan* and the government's *Risk Management Plan*.



Define risks with respect to key issue areas

Risk Issue Area: Project Management

Strengths:

Weaknesses:

Improvement Activities:

Findings:

- benefit contractor's development
- help raise maturity level
- identify key risks to the program

Outline

This section of the presentation describes SDIO's approach for using the software process maturity model to motivate contractors to improve their software development practices.

Outline



1. SEI Software Process Maturity Model
2. Software Process Evaluation Activities
3. SDI Implementation Plans
4. Benefits and Lessons Learned



Applications of Capability Evaluations

SDIO plans to use capability evaluations for both contract monitoring and for source selection.

Contract Monitoring: Evaluations help monitor and motivate the Demonstration/Validation (Dem/Val) contractors. Since 86% of the contractors are thought to have immature processes, it is necessary to give the contractors an opportunity to improve before the evaluation results are used as a source selection criteria. Since it generally takes several years for a contractor to advance from one level to the next, they need time to implement and improve their process.

Capability evaluations should be performed annually during Dem/Val and Engineering Manufacturing and Development (EMD) phases of the acquisition life cycle. The Award Fee should be based on the results of these evaluations.

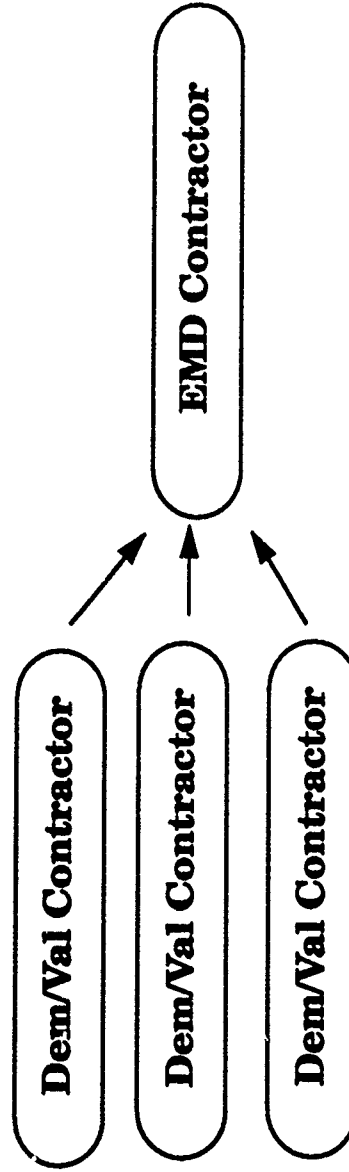
Source Selection: The results of capability evaluations help the source selection advisory board select the best contractor for developing SDI software. When the evaluations are used for source selection, the team evaluates all prime contractors bidding on the contract. But if the number of bidders is too great, there are several ways to limit the number of contractors requiring evaluations. For example, the evaluations could be performed only on the Best and Final Offerors (BAFOs) or the contract may be awarded on the basis that the contractor is able to meet the acceptable maturity level.

Applications of Capability Evaluations



**Contract
Monitoring**

**Source
Selection**



SDI Evaluation Team

The SDI Capability Evaluation Team will consist of 5-6 software experts. Since the quality of the evaluation is dependent on the quality of the team members, each member must have at least 7 years of experience in either software acquisition or software development. Since training is costly, it would also be beneficial to have the team members available to perform evaluations for at least the next 2-3 years.

The teams will contain 1-2 representatives from the Program Office responsible for the contract. The program office representatives will benefit from insights brought forth during an evaluation and they will help provide specific knowledge of the contractual issues affecting the contractor's software process. The remainder of the team will be multi-service, drawing from the experience of the Army, Air Force, National Test Bed, and SDIO. Since these resources are limited, the teams will also use representatives from FFRDCs and National Labs that support the SDI (e.g., IDA, Sandia, or Los Alamos).

SDI Evaluation Team



Team Member Qualifications:

- Minimum 7 years acquisition or software development
- Available for 2-3 years

Team composition:

- Program Office Representative (s)
- Air Force SSD
- Army SDC
- NTB
- SDIO

6 Member team (including 1 alternate)

SDI Contract Monitoring Process

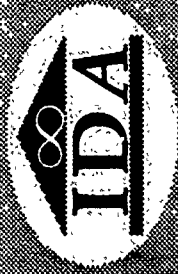
Due to the large number of contractors involved in the program, it is SDIO's goal to leverage the success of the contractor's self-assessments and use a top-down approach for capability evaluations. SDIO Software Policy and Directive (3405) specifies the following:

Self Assessments: The subcontractors and the prime contractors are encouraged to perform annual self assessments of their development processes and to develop annual *Software Process Improvement Plans*. The self assessments place the responsibility of risk identification and process improvement on the contractor. The Process Improvement Plans are also essential since that is the vehicle for ensuring process improvement occurs.

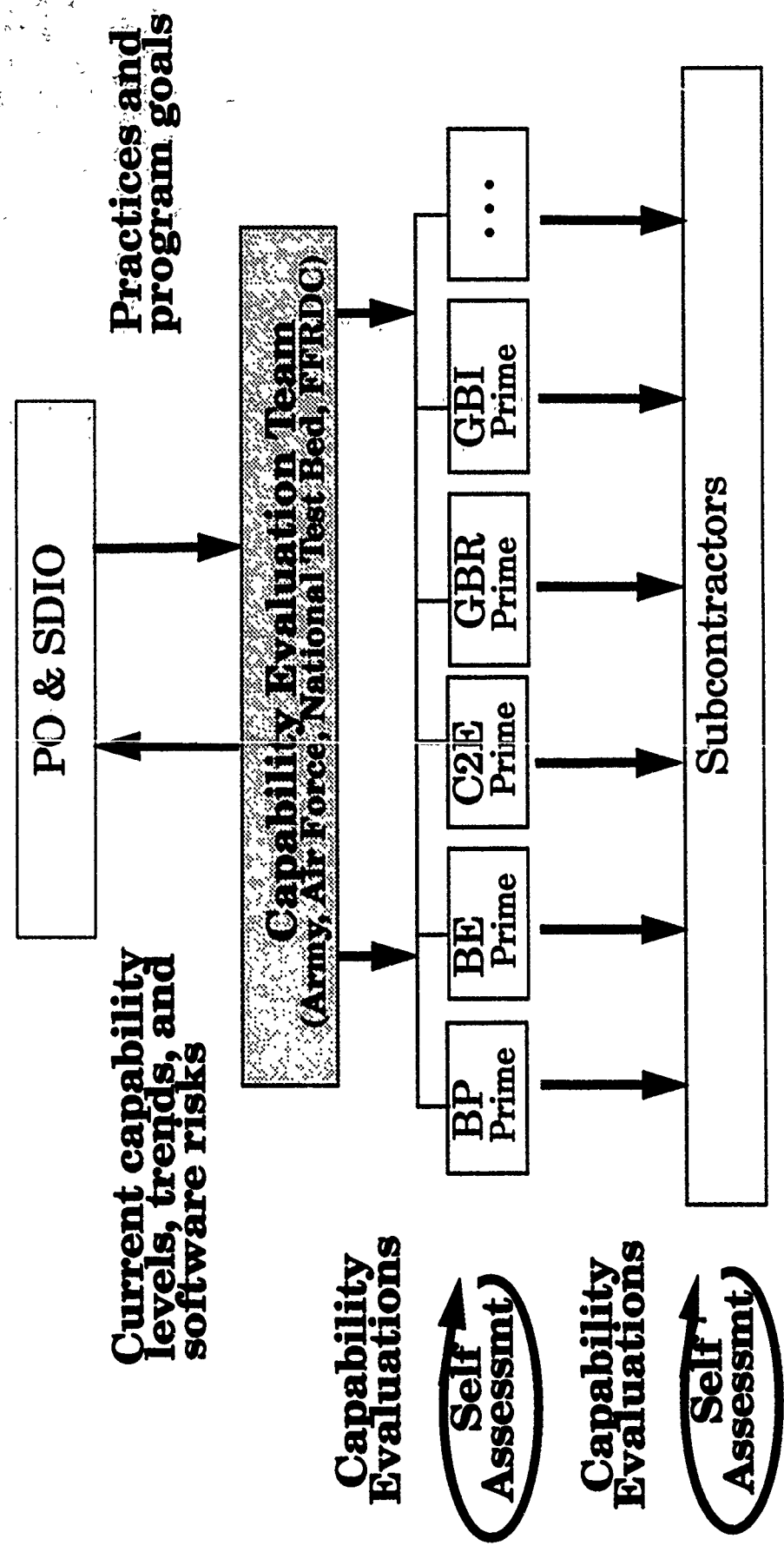
The combination of self assessments and Process Improvement Plans encourage continuous improvement within the DoD contractor community.

Capability Evaluations: Since the prime contractors are responsible for the quality and cost of their subcontractor's software, SDIO requires the prime contractors to perform annual Capability Evaluations on their subcontractors. The SDI Capability Evaluation team then only evaluates prime contractors and not all subcontractors. But they will look closely at how well the prime contractors oversee their subcontractors and will validate the results of the self-assessments and the *Software Process Improvement Plans*.

The results of the SDI Capability Evaluations are provided to the contractor and the element program managers for input to their risk management process. In order to identify and track the software risks across the program, SDIO will also maintain a database of all the evaluation results.



SDIC Communication and Planning Process



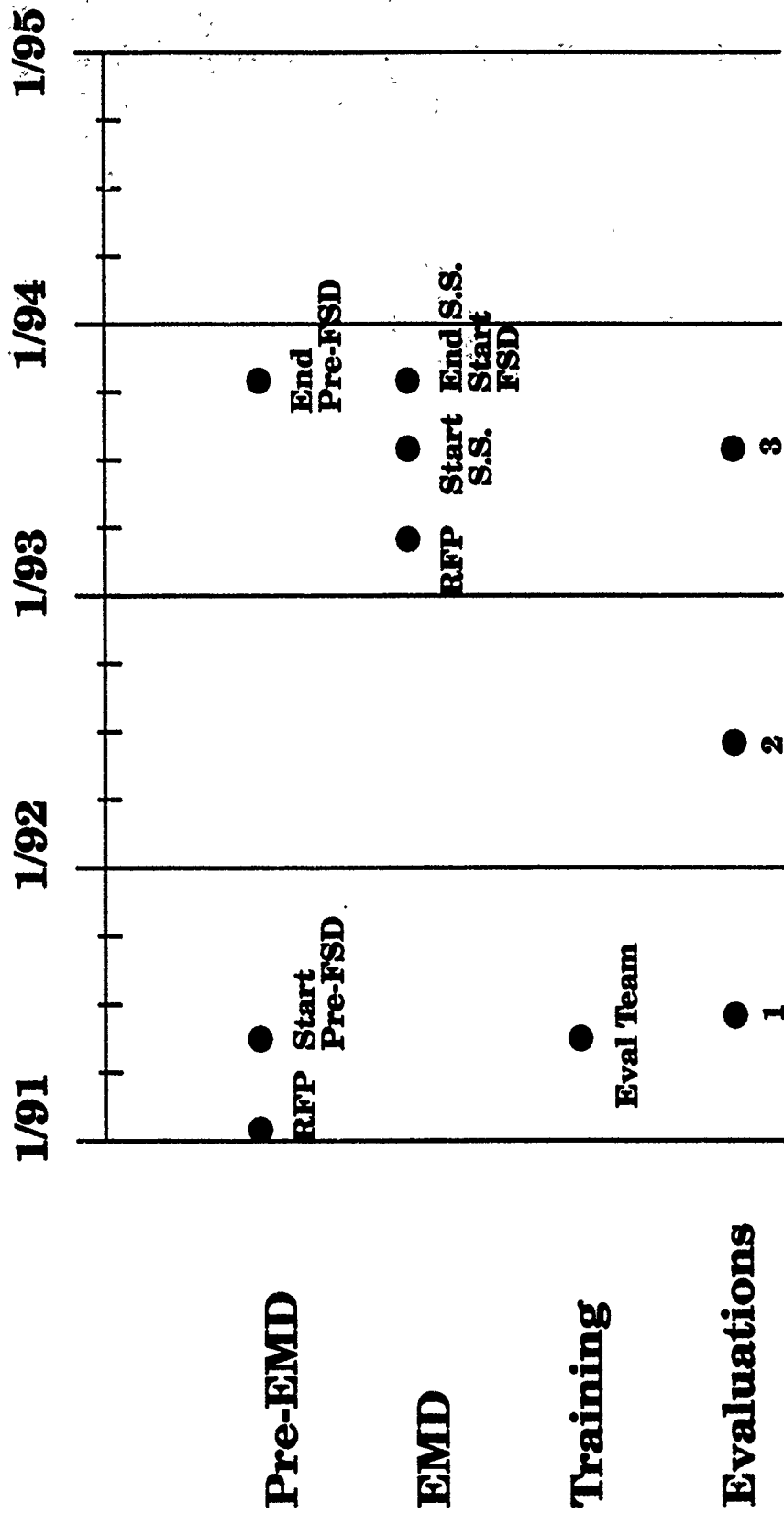
Implementation Plan

As previously discussed, capability evaluations can be used for contract monitoring and source selection. For example, the Brilliant Pebbles' contract calls for annual capability evaluations during Dem/Val; one at the beginning, middle, and the end of the contract. In each case, the evaluation will determine the contractor's strengths and weaknesses relative to maturity level 3. The results of the last evaluation will be given to the EMD source selection evaluation board.



Implementation Plan

e.g. Brilliant Pebbles Plan



S.S.: Source Selection

Inputs to RFP

In order to use the maturity model on a contract, the RFP should identify it as a requirement. Following are the specifics that must be included in the RFP:

Dem/Val & EMD Contracts: The contractor shall provide resources to support an independent team of up to eight software experts that will perform a series of evaluations of the contractor's software development process. This team shall utilize the SEI evaluation process to determine the contractor's software process maturity level. The evaluation shall be based on the contractor's software development process as documented in the Software Development Plan and by prior accomplishments. The evaluations shall extend up to 5 consecutive days on an annual basis; within 6 months of contract award, during the middle of the contract, and during the last 6 months of the contract.

The contractor is encouraged to provide resources and support to perform annual self assessments of their software development process during the Dem/Val contract period. These assessments shall be in accordance with the SEI software process maturity model. The contractor is also encouraged to define, develop and implement a software development process improvement plan that shall raise the contractor's maturity level by the end of the contract.

The contractor shall provide resources to perform corresponding assessments for all subcontractors that have responsibility for software development.

EMD Source Selection Criteria: The government will evaluate the offeror's software process by reviewing the offeror's software process improvement plan and by using the SEI capability evaluations. A risk assessment to compare proposed practices to current validated practices may be performed. The evaluation will determine the offeror's strengths and weaknesses in key process areas relative to maturity level 3, as defined by the SEI. These strengths and weaknesses will form the basis for determining the software process capability of the bidding organization. (PRISM 91)

UNCLASSIFIED

Inputs to RFP



Dem/Val Contract Monitoring:

Prime contractor evaluations

- Annual government capability evaluations
- Contractor self assessments
- Contractor's process improvement plan

Subcontractor evaluations

- Annual prime contractor capability evaluations
- Subcontractor self assessments
- Subcontractor's process improvement plan

EMD Source Selection:

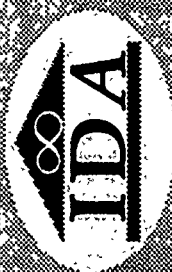
Evaluate contractor's process relative to maturity level 3

EMD Contract Monitoring: (same as Dem/Val)

Status of SDI Evaluations

The SDI Capability Evaluations will be used on at least 9 different elements and 22 different contractors over the next year, beginning in September 1991. The evaluations will be used for monitoring the Dem/Val contract and for identifying program risks. As these programs approach EMD, it is SDIO's intention to use the evaluation results as source selection criteria.

To accommodate the demand for 22 evaluations, SEI will train four or five SDI software evaluation teams. The teams will attend the training course approximately 3 months in advance of the first evaluations.



Status of SDI Evaluations

<u>SDI Elements</u>	<u>Est. No. of Evaluations</u>	<u>Est. Date of Evaluation</u>	<u>Training Schedule</u>
BE	4	April 92	Jan 92
BP	2	Sep/Dec 91	(done)
C2E	1	*	*
E2I	3	*	Nov 91
GBI	3	*	*
GBR	4	July 92	Feb 92
GSTS	2	June 92	Feb 92
NTB	2	*	*
THAAD	1	June 92	*
	<u>22</u>		

* To Be Determined

UNCLASSIFIED

Expenses for Capability Evaluations

The expense of performing an SDI evaluation includes training and travel expenses. The cost of training a 6 member evaluation team is approximately \$15,500 resulting in a total cost of \$62,000 for training 4 teams. The cost of a 3 day site visit is approximately \$10,000 per contractor. Thus the total cost of performing 22 evaluations is approximately \$282,000, including training and evaluation expenses.

Currently, SDIO will pay these expenses for the SDI Program Offices that wishes to use the capability evaluations for source selection or contract monitoring.

Expenses for Capability Evaluations



Training Course Expenses: (Assuming 4 teams) \$ 62,000

\$15,500 x 4 teams

SDIO Evaluation Expenses: (Assuming 22 evaluations) 220,000

\$10,000 TDY/visit x 22 visits

- 3 GBI
- 3 E2I
- 4 GBR
- 2 GSTS

- 4 BE
- 2 BP
- 1 NTB
- 1 C2E
- 1 THAAD

\$ 282,000

Outline

This section describes the benefits and lessons learned of performing two software process evaluations.



Outline

1. SEI Software Process Maturity Model
2. Software Process Evaluation Activities
3. SDI Implementation Plans
- 4. Benefits and Lessons Learned

Benefits

The combination of capability evaluations, self assessments, and process improvement plans encourage contractors to continuously improve their software development process.

Capability evaluations enable the government to select and manage software contracts. It is a good mechanism to help the government select low risk contractors that are more likely to produce software on time and within budget. It also gives the government visibility into the contractor's process on an on-going basis.

The capability evaluations are also beneficial to the contractor. It provides them an independent view of their software practices.

Self Assessments are effective for helping the contractor identify strengths and weaknesses within their development process. They also help to benchmark the effects of their process improvement plans.

Process improvement plans ensure that both the evaluations and assessments have an impact on improving the contractor's process. These plans are the contractor's vehicle for prioritizing risks, establishing resources, and obtaining management commitment to reduce risks. They are generally updated every 12-24 months, after a self assessment or capability evaluation.



Benefits

Software Capability Evaluations: (performed by SDI's evaluation team)

- Provide independent evaluation for companies and program office
- Facilitate development of contractor's improvement plan
- Enhance ability of government to select and manage software contractors

Software Self-Assessments: (performed by contractor's team)

- Help contractor characterize current software practices
- Assess progress of improvement against goals

Process Improvement Plans: (developed by contractor's team)

- Establish priorities for risk abatement and process improvement
- Help contractor identify activities, resources, and management commitment necessary to improve software process

Lessons Learned

After completing two SEI Capability Evaluation, both contractors said the findings were representative of their process. But there are several recommendations that will be incorporated in future evaluations.

Documentation: There should be ample time in the schedule for the evaluation team to review the documentation sent in advance of the site visit. It is very common for the contractor to send the information later than requested which causes undue stress on the team.

Overview Briefing: To make the contractor's overview briefing as informative as possible, the contractor needs specific directions on what to present to the evaluation team.

Team Handbook: Since every team member brings different strengths and weaknesses to the team, it would be helpful to have a brief tutorial on each process areas to reference, probing interview questions for each area, and a list of supporting documentation to request. In addition, the handbook should identify the coordination activities made before and after the evaluation.

Acquisition Knowledge: It would be beneficial for the evaluation team to know about the specific acquisition prior to the evaluation. The team should be aware of what is in the contract, the players, and any unique requirements that need special attention.

Team Rules: In order for the team to be efficient and effective, some ground rules should be discussed ahead of time; for example, all interviews should be done with the team and outside meetings should not interrupt an evaluation.

Documentation archives: Depending on the nature of the evaluation, certain documentation should be collected in order to defend specific evaluation results in the future. This level of detail is currently undecided.



Lessons Learned

- **Documentation**; request contractor information 3-4 weeks prior to visit
- **Overview Briefing**; give more direction for contractor's overview brief
- **Handbook**; develop brief tutorial on each key process area, interview questions, and supporting documentation
- **Acquisition**; obtain knowledge of specific acquisition
- **Team rules**; establish Team Rules; e.g., no individual interviews
- **Documentation archives**; Determine appropriate documentation to archive

Suggestions for Further Reading

- (Bollinger 91) Bollinger, I. and C. McGowan. 1991. *A Critical Look at Software Capability Evaluations*. IEEE Software 8 (July 1991):25-41.
- (Deming 86) Deming, W.E., 1986. *Out of the Crisis*. Cambridge, MA: MIT Center for Advanced Engineering Study.
- (Fowler 90) Fowler P. and S. Rifkin. 1990. *Software Engineering Process Group Guide*. Pittsburgh, PA: Software Engineering Institute. SEI Technical Report, SEI-90-TR-24.
- (Humphrey 87) Humphrey, W.S. and W.L. Sweet. 1987. *A Method for Assessing the Software Engineering Capability of Contractors*. Pittsburgh, PA. Software Engineering Institute. SEI Technical Report, SEI-87-TR-23.
- (Humphrey 89a) Humphrey, W.S. 1989. *Characterizing the Software Process*. IEEE Software 5 (March 1988): 73-79.
- (Humphrey 89b) Humphrey, W.S. 1989. *Managing the Software Process*. Reading, MA: Addison-Wesley.
- (Humphrey 89c) Humphrey, W.S., D.H. Kitson, and I. Kasse. 1989. *The State of Software Engineering Practice: A Preliminary Report*. Pittsburgh, PA. Software Engineering Institute. SEI Technical Report, SEI-89-TR-1.
- (Humphrey 90) Humphrey, W.S. 1990. *Software Process Program Briefing*. Pittsburgh, PA. Software Engineering Institute.
- (Humphrey 91a) Humphrey, W.S., T.R. Snyder, and R.R. Willis. 1991. *A Software Process Improvement at Hughes Aircraft*. IEEE Software 8 (July 1991):11-23.

Suggestions for Further Reading (cont.)

- (Humphrey 91b) Humphrey, W.S. and B. Curtis. 1991. *Comments on 'A Critical Look'*. IEEE Software 8 (July 1991):42-46.
- (Juran 88) Juran, M. 1988. *Juran on Planning for Quality*. New York, NY: Macmillan.
- (Pore 90) Pore, M. 1990. *Implementing a Software Quality Improvement Program*. 2nd Annual Software Quality Workshop, August 14-16, 1990. Rochester, NY.
- (PRISM 91) Portable, Reusable, Integrated Software Modules (PRISM). 1991. PRISM Draft RFP No. F19628-91-0016. Hanscom Air Force Base, Bedford, MA.
- (Rugg 90) Rugg, D.L. 1990. *Use of the Software Engineering Institute's Method for Assessing the Software Engineering Capability of Contractors*. Weapons Systems Software Office, Aircraft Weapons Integration Department.
- (SEI 91a) Software Engineering Institute. 1991. *Evaluation Team Training: Participant's Handbook*. Pittsburgh, PA.
- (SEI 91b) Software Engineering Institute. 1991. *Software Capability Evaluation Overview: Participant's Handbook*. Pittsburgh, PA.
- (Willis 90) Willis, R.R. 1990. *Case History and Lessons Learned in Software Process Improvement*. NSIA Conference on Software Quality and Productivity. Williamsburg, P.A.

Distribution List for IDA Document D-1042

NAME AND ADDRESS	NUMBER OF COPIES
-------------------------	-------------------------

Sponsor

Lt Col James Sweeder SDIO/SDA The Pentagon, Room 1E149 Washington, DC 20301-7100	3
---	---

Other

Defense Technical Information Center Cameron Station Alexandria, VA 22314	2
---	---

Dr. Dan Alpert, Director Program in Science, Technology & Society University of Illinois Room 201 912-1/2 West Illinois Street Urbana, Illinois 61801	1
--	---

Axel Ahlberg GE Aerospace National Test Facility MS-N9020 Falcon AFB, CO 80912-5000	1
---	---

Capt. Emily B. Andrew Software Engineering National Test Bed Falcon AFB, CO 80912-5000	1
---	---

Lt Col Roy Aydelott SDIO The Pentagon Washington, DC 20301-7100	1
--	---

NAME AND ADDRESS	NUMBER OF COPIES
Charles Bailey US Army SDC SFAE-SD-GBR PO Box 1500 Huntsville, AL 35807-3801	1
Lynwood Bailey US Army SDC CSSD-KE-F PO Box 1500 Huntsville, AL 35807-3801	1
Dr. James Carlson Deputy for Strategic Defense SDIO The Pentagon Washington, DC 20301-1700	1
Mr. Jerry Cavender US Army SDC SFAE-SD-GST PO Box 1500 Huntsville, AL 35807-3801	1
Col. Kenneth Collins Acquisition and Mission Operations SDIO Washington, DC 20301-1700	1
Jackie Cristina US Army SDC CSSD-SA-BT PO Box 1500 Huntsville, AL 35807-3801	1
Col. Carl Drewes Deputy for Strategic Defense SDIO The Pentagon Washington, DC 20301-1700	1

NAME AND ADDRESS	NUMBER OF COPIES
Capt. Tim Fisk USAF SSD Attn: CNI PO Box 92960 Los Angeles AFB, CA 90009	1
Col. Richard Gajewski SSD/CNSE PO Box 92960 LA Air Force Base, CA 90009-2960	1
Dr. Clarence Giese NTBJPO/ITC Falcon AFB, CO 80912-5000	1
Dr. Ronald Green US Army SDC CREO PO BOX 1500 Huntsville, AL 35807-3801	1
Norman Goddard US Army SDC SFAE-SD-HED PO Box 1500 Huntsville, AL 35807-3801	1
Ron Halbgewachs POET 1225 Jefferson Davis Hwy Suite 300 Arlington, VA 22202	1
Lt Col Alan Hammond US Army Strategic Defense Command CSSD-TM-I PO Box 1500 Huntsville, AL 35807-3801	1
Lt Col Richard Hochberg SDIO The Pentagon Washington, DC 20301-7100	1

NAME AND ADDRESS	NUMBER OF COPIES
Dr. Jim Hooper c/o University of Alabama in Huntsville Computer Science Dept. Huntsville, AL 35899	1
Richard Iliff SDIO/SDA The Pentagon, Room 1E149 Washington, DC 20301-7100	1
Mr. David Israel SDIO The Pentagon Washington, DC 20301-1700	1
Myong Jensen Dynamics Research Corp 1755 Jefferson Davis Hwy Suite 802 Arlington, VA 22202	1
Mr. James Katechis US Army SDC SFAE-SD-GBI PO BOX 1500 Huntsville, AL 35807-3801	1
Mr. Jim Kesting US Army Strategic Defense Command CSSD-TN-S PO Box 1500 Huntsville, AL 35807-3801	1
Jack Kleinert SAIC 1710 Goodridge Drive McLean, VA 22102	1
Dr. Virginia Kobler US Army SDC CSSD-SA-BT PO Box 1500 Huntsville, AL 35807-3801	1

NAME AND ADDRESS	NUMBER OF COPIES
Capt. Jonathan Liles SSD/CNSE PO Box 92960 LA Air Force Base, CA 90009-2960	1
Mr. Paul Lynch US Army Strategic Defense Command CSSD-TM-H PO Box 1500 Huntsville, AL 35807-3801	1
Barbara Mered GE Aerospace 1225 Jefferson Davis Hwy Arlington, VA 22205	1
Col Paul Mullek US Army SDC CSSD-SA-E PO Box 1500 Huntsville, AL 35807-3801	1
Ron Neal HQ SSD Attn PL/XP PO Box 92960 Los Angeles AFB, CA 90009	1
Maj. Jack Owens US Army SDC PO Box 1500 Huntsville, AL 35807-3801	1
Frank Poslajko US Army SDC CSSD-CR-S PO Box 1500 Huntsville, AL 35807-3801	1
Col. Richard Ritter SDIO The Pentagon Washington, DC 20301-1700	1

NAME AND ADDRESS**NUMBER OF COPIES**

Mr. Roy Roberts
US Army Strategic Defense Command
CSSD-TM-S
PO Box 1500
Huntsville, AL 35807-3801

1

Bill Robertson
US Army SDC
SFAE-SD-GBI
PO Box 1500
Huntsville, AL 35807-3801

1

Col. Raymond Ross
Deputy for Theatre Missile Defense
SDIO
The Pentagon
Washington, DC 20301-1700

1

Col. William Ryan
US Army SDC
SFAE-SD-GBR
PO Box 1500
Huntsville, AL 35807-3801

1

Dr. Jim Sanderson
Los Alamos Natl Lab
PO Box 1663
MEE-10, MS K488
Los Alamos, NM 87545

1

Doyce Satterfield
US Army SDC
CSSD-AT-P
PO Box 1500
Huntsville, AL 35807-3801

1

Mr. Alan Sherer
US Army SDC
SFAE-SD-GST
PO Box 1500
Huntsville, AL 35807-3801

1

NAME AND ADDRESS	NUMBER OF COPIES
Ken Shipman US Army SDC CSSD-TM-H PO Box 1500 Huntsville, AL 35807-3801	1
Dr. Terry Starr GE Aerospace PO Box 1000 Blue Bell, PA 19422	1
Carol Taylor NSA Attn V31 9800 Savage Road Ft. Meade, MD 20755	1
Jim Van US Army SDC SFAE-SD-GST PO Box 1500 Huntsville, AL 35807-3801	1
Joel Williams USAF SSD Attn CNI PO Box 92960 Los Angeles AFB, CA 90009	1
Col. Roland Worrell SDIO The Pentagon Washington, DC 20301-1700	1

IDA

General Larry D. Welch, HQ	1
Mr. Philip L. Major, HQ	1
Dr. Robert E. Roberts, HQ	1
Ms. Ruth L. Greenstein, HQ	1
Dr. Richard J. Ivanetich, CSED	1
Ms. Anne Douville, CSED	1
Mr. Terry Mayfield, CSED	1
Ms. Sylvia Reynolds, CSED	2
Dr. Richard L. Wexelblat, CSED	1
Dr. Dennis Fife, CSED	5
Ms. Beth Springsteen, CSED	20
IDA Control & Distribution Vault	3